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Limestone Screenings As a Substitute for Sand in Mortar & Concrete

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LIMESTONE SCREENINGS

AS A SUBSTITUTE FOR

SAND IN MORTAR AND CONCRETE

...BY...

Guy Henry Rump

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN CIVIL ENGINEERING

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GUY HENRY RUMP

ENTITLED LIMESTONE SCREENINGS AS A SUBSTITUTE FOR SAND IN MORTAR AND CONCRETE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Bachelor of Science in Civil Engineering.

Ira O Baker

HEAD OF DEPARTMENT OF Civil Engineering

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Concrete is a structural material which on account of its adaptability to different kinds of work has come into very general use in recent years. Investigations in regard to its properties have not in all respects kept pace with the extent of its use, and as a result there are still some differences of opinion concerning its use and manufacture. For example, there has been some dispute and some litigation as to whether in making concrete, stone screenings or "crusher dust" could be substituted for sand. A case of recent date is that of the Jerome Park Reservoir, in which the engineer in charge was brought into court by the New York Merchants' Association for using crushed granite in the place of sand in the concrete construction of the dam. On the other hand, the Chicago Rock Island and

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Pacific Railroad in the construction of their new depot in Chicago, used crushed limestone from old buildings in the concrete and employed the screenings in place of sand. Again, in the construction of the New York Rapid Transit Tunnel under East River, "crusher dust" was used in the grouting surrounding the cast-iron lining. Further, in the author's home town a prominent construction company, while doing work for themselves, used limestone screenings in preference to good river sand which could be had within 500 yards without cost.

In view of this difference in practice the author decided to make some experiments in order to determine the value of limestone screenings when used in the place of sand in mortar and in concrete.

Two sets of experiments were made the first to determine the value of limestone screenings in mortar, and the second to determine their

value in concrete.

Six different kinds of materials were used as sand in the tension tests:

1. Standard american sand,-crushed quartz passing a 30 and caught on a 20 sieve, having sharp and angular grains and 56 per cent of voids

2. German standard sand,- a natural sand consisting of rounded quartz grains passing a 30 and caught on a 20 sieve and having 41 per cent of voids

3. Screened building sand,-a natural sand of glacial origin containing more or less clay and friable material, passing a 30 and caught on a 20 sieve and having 43 per cent of voids

4. Screened limestone screenings,- the refuse of the crusher, passing a 30 and caught on a 20 sieve and having 43 per cent of voids.

5. Unscreened building sand,- from the same bank as No. 3, having 32 per cent of voids.

6. Unscreened crusher refuse - the same as No. 4 unscreened, ranging from dust to grains the size of a pea and having 31 per cent of voids. These screenings were Kankakee limestone and had been run through a pulverizer but had not been dusted.

Tension Tests

A 1:3 mixture of each of the different sands and of Chicago A A Portland cement with ten per cent of water was used in making the mortar for these tests. The briquetts were made by pressing the mortar into the moulds in layers with the thumb, care being taken to make them as uniform as possiable. The moulds were covered with a damp cloth, and after about 20 hours the briquetts were placed in flowing water where they remained until broken. Table I shows the results of these tests.

TABLE I

TENSILE STRENGTH OF 1 TO 3 MORTAR WITH DIFFERENT KINDS OF SANDS

POUNDS PER SQUARE INCH

NO.1 STANDARD AMERICAN SAND	NO.2 STANDARD GERMAN SAND	NO.3 20-30 BUILDING SAND	NO.4 20-30 LIMESTONE SCREENINGS	NO.5 UNSCREENED BUILDING SAND	NO.6 UNSCREENED LIMESTONE SCREENINGS
		AGE 7 DAYS			
104	95	105	107	112	125
127	95	62	110	107	135
135	117	56	150	110	109
107	84	70	125	118	95
105	102	65	136	112	165
115	99	72	126	112	126
		AGE 4 WEEKS			
130	172	109	179	177	212
175	115	135	197	128	200
185	135	105	198	163	174
151	125	96	175	130	253
170	150	93	197	140	155
162	139	107	189	148	199
	PER CENT INCREASE OF 4 WEEKS OVER 7 DAYS				
29	41	47	51	25	59

In Table I notice that the sand in the first four colums is of the same degree of fineness, and that the limestone screenings give the strongest mortar for both ages. Again notice that the sands in the last two colums of the table have the same degree of fineness, and that the limestone screenings again for both ages give the greatest strength. Notice also that the per cent of increase in strength at four weeks over that of seven days is greatest for both grades of limestone screenings. It is worthy of remark that the unscreened limestone screenings give a greater strength for both ages than any other of the sands, and that the per cent of increase from seven days to four weeks is also the greatest, both of which facts show that the fine particles, even dust, are not a detriment.

Compression Tests

In these experiments two grades of limestone were used - unscreened crusher-run stone ranging from 1½-inch to dust, and stone passing a 1½-inch and caught on a ¼-inch screen. Three kinds of sands were used: limestone screenings, the same as No 6 in the mortar tests; building sand (a), the same as No 5 in the mortar tests; building sand (b) consisting of clean sharp silica grains. The latter sand is used by the Wabash Railroad and is of an excellent quality - as was shown by other tests not here mentioned.

The concrete in each case was composed of 1 part Chicago A A Portland cement, 3 parts of one of the sands previously described, and 5 parts of one of the two above grades of broken stone. The concrete was rammed into 6" by 6" by 6" moulds in three layers with fifty blows of a 50 Kilo rammer to a layer.

every precaution being taken to make the cubes as uniform as possiable. The cubes were left about 20 hours in the moulds and were then stored in water until broken.

Four series of cubes were made having the following composition:
No. 1, crusher-run broken stone and building sand (a);
No. 2, crusher run broken stone and limestone screenings;
No. 3, ¼" to 1½" broken stone and building sand (b);
No. 4, ¼" to 1½" broken stone and limestone screenings.

TABLE II

COMPRESSIVE STRENGTH OF 1 TO 3 CONCRETE.

POUNDS PER SQUARE INCH.

NO.1 CRUSHER-RUN STONE AND BUILDING SAND(a)	NO.2 CRUSHER-RUN STONE AND LIMESTONE SCREENINGS	NO.3 ½" TO 1½" CRUSHED STONE AND BUILDING SAND(b)	NO.4 ½" TO 1½" CRUSHED STONE AND LIME-STONE SCREENINGS
	AGE: 7 DAYS		
694	803	1128	1185
471	500	907	1043
876	938	1218	1250
680	745	1085	1160
	AGE: 4 WEEKS		
774	1145	2250	2022
1550	638	2180	2240
861	1288	1625	2370
897	1150	2010	2210
	AGE: 3 MONTHS		
1135	1120	2185	1830
862	1210	2920	2920
556	1082	2020	2330
850	1170	2380	2360

Table II shows that with the same stone the limestone screenings give a stronger concrete than does either of the two grades of building sand, with the single exception of the three months tests of No 4. Building sand (A) tested 20 pounds, or less than 1 per cent higher than did the limestone screenings in the three months tests of No. 4; but taking into consideration the range of the strength of the different cubes in tests No. 3 and No. 4, the mean results may be considered practically the same. Some of the cubes in the three months tests, and especially those which were a little dryer than the rest, broke lower than was expected. It was the intention to store the cubes in a tank through which the water was gently flowing; but through an error of another party the flow was cut off between the one-month and the three-month tests, and as a consequence

the water in the tank became very stale and slimy. This would prevent the concrete from gaining strength and probably accounts for the slight difference between the results for the four weeks and the three-months tests. This was more noticeable in the cubes which absorbed considerable moisture and especially so in the case of the three months tests of No. 1; these cubes were made with an inferior grade of sand and were mixed rather dry.

By comparing the first two columns of Table II with the last two columns, it appears that unscreened stone gives a weaker concrete than screened stone, which is contrary to the usually accepted theory. This anomalous result is apparently due to the fact that the crushed stone consisted of two distinct grades, - one a hard and flinty material, and the other soft and partially decomposed.

The stone was ordered in a distant city, and after its arrival and the discovery of its quality, it was impossiable to procure other material. With this peculiar combination of materials the crushing stone contains a surplus of soft fine material and therefore gives a less strength than when the soft material is screened out.

The time available and other conditions did not permit of a more thorough investigation of this subject; but these experiments go to show that screenings from moderately hard limestone give greater strength in mortar in tension and as great a strength in concrete in compression as does the best natural sand. Therefore, it may be concluded that when limestone screenings are available, they may safely if not preferably be substituted in both mortar and concrete for the best of natural sand.

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